

Jason 1 Investigation: Altimetric Studies of Ocean Tidal Dynamics

Summary of Research

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Research Summary:

This project was a one year continuation of long-running collaboration with R.D. Ray, NASA/GSFC, on studies of large-scale tidal dynamics and energetics using TOPEX/POSEIDON and JASON data. Principal areas of study have been energy dissipation and conversion to internal tidal motions, long period tidal dynamics, and data assimilation methods for mapping tidal elevation and current fields in the global ocean. The most important overall finding of this effort, presented in a series of four papers (Egbert and Ray, 2000, 2001, 2003b; Egbert et al., 2004) was that approximately one third of all semi-diurnal tidal dissipation occurs in the deep ocean. The deep ocean dissipation is concentrated in areas of rough bottom topography, particularly over ridges and island arcs oriented perpendicular to barotropic tidal flows, almost certainly reflecting conversion from barotropic (surface) to baroclinic (internal) tidal motions. Summed over all constituents approximately 1TW of dissipation occurs in the deep ocean. Tides may thus be an important source (along with winds) of mechanical energy for vertical mixing in the deep ocean. A second focus of effort was on understanding long period (fortnightly and monthly) tides and their deviation from equilibrium form (Egbert and Ray, 2003a). The project also provided continued support for development of new versions of the OSU global tidal inverse solution, which has been widely used to provide tidal corrections for oceanographic and geophysical data, as well as open boundary forcing for tides in regional ocean modeling. The most recent version, TPXO.6 is available over the internet from <http://www.coas.oregonstate.edu/po/research/tide>.

Over the past year this grant supported continued work on this longer-term project. Specific accomplishments over the past year include completion and publication of two papers on tidal dissipation. The first of these (Egbert and Ray, 2003b) extended our earlier work, which focused on the dominant M2 constituent, to include 7 additional constituents. In addition to confirming a total deep water dissipation total very close to 1 TW, this study demonstrated significant differences in the distribution of dissipation between diurnal and semi-diurnal constituents. The second paper (Egbert et al., 2004) involved an extensive modeling study of tides in the present day and the last glacial maximum. In this study we showed that accuracy of tidal solutions for the present day ocean were significantly improved by including a parameterization of internal tide drag over rough topography in the deep ocean. It was also demonstrated that a complete self-consistent treatment of ocean self attraction and tidal loading was required for accurate solutions. After verification on the present day ocean, where altimetry constrains tidal elevations in the open ocean, we experimented with ocean bathymetry appropriate to the last glacial maximum (LGM). Total tidal dissipation was found to increase substantially when sea level was dropped to LGM levels, with dissipation especially enhanced in open ocean areas. Although details depended on assumptions about stratification of the ocean during the LGM, the tendency to increase in both deep ocean and total dissipation was a robust feature of all stratification scenarios tested. Over the past year we also completed a paper on the global S1 tide (Ray and Egbert, 2004). In this study we compared purely empirical estimates of S1 tidal elevations obtained from analysis of TOPEX/POSEIDON data with numerical solutions obtained by forcing the shallow water equations with estimates of the atmospheric S1 tide obtained from analysis of ECMWF analysis products. Good agreement was found, with largest amplitudes in both empirical and numerical tidal solutions in the Arabian Sea and North Pacific. Similarities and differences between the atmospherically forced S1 tide, and the

gravitationally forced K1 tide (almost identical frequencies) can be explained in terms of the projection of the differing spatial patterns of the forcing onto the normal modes of the global ocean. Over the past year the grant also provided support for Research Associate Lana Erofeeva's effort on developing improved models for the Arctic Ocean (Padman and Erofeeva, 2004). The improved Arctic model is being incorporated in new versions of our global tidal solution.

References

Egbert, G. D., and R. D. Ray, Significant tidal dissipation in the deep ocean inferred from satellite altimeter data, *Nature*, 405, 775-778, 2000.

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Egbert, G. D, and R. D. Ray, Deviation of long period tides from equilibrium: kinematics and geostrophy, *J. Phys. Ocean*, 33, 822-839, 2003a.

Publications supported by this grant:

Egbert, G. D., and R. D. Ray, Semi-diurnal and diurnal tidal dissipation from TOPEX/POSEIDON altimetry, *Geophys. Res. Lett.*, 30(17), 1907, doi:10.1029/2003GL017676, 2003b.

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Padman, L., and S. Erofeeva, A barotropic inverse tidal model for the Arctic Ocean, *Geophys. Res. Lett.*, 31, L02303, doi:10.1029/2003GL019003, 2004.

Ray, R. D., and G. D. Egbert, The global S₁ tide, *J. Phys. Ocean.*, in press, 2004.

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13. ABSTRACT (Maximum 200 words) Two papers on tidal dissipation were completed and published. The first of these extended our earlier work, which focused on the dominant M2 constituent, to include 7 additional constituents. In addition to confirming a total deep water dissipation total very close to 1 TW, this study demonstrated significant differences in the distribution of dissipation between diurnal and semi-diurnal constituents. The second paper involved an extensive modeling study of tides in the present day and the last glacial maximum. In this study we showed that accuracy of tidal solutions for the present day ocean were significantly improved by including a parameterization of internal tide drag over rough topography in the deep ocean. It was also demonstrated that a complete self-consistent treatment of ocean self attraction and tidal loading was required for accurate solutions.				
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